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BIOLOGY.—*Speculation on the cosmic function of life.* A. A. WILLIAMSON, Washington, D. C. (Communicated by Waldo L. Schmitt.)

“... the demonstration of the existence of a general trend which can legitimately be called progress, and the definition of its limitations, will remain as a fundamental contribution of evolutionary biology to human thought.”—JULIAN HUXLEY.

The principles or laws of thermodynamics have been variously stated. The most succinct formulation of the so-called first law of thermodynamics was given by Rudolf Clausius in 1850: that the energy of the universe is constant. This is the principle of the conservation of energy: it can be neither created nor destroyed. Clausius also formulated what is known as the second law of thermodynamics: that the entropy of the universe tends to a maximum. This is the principle of the dissipation of energy, theoretically ending in the “heat-death” of the universe when all energy will be uniformly distributed at a dead level of ineffectiveness.

At first sight, these two laws seem contradictory. For if cosmic energy, however indestructible, tends to reach a common dead level at which it can perform no more work, then is it not thereby reduced to zero? Is not that what the theoretic “heat-death” of the universe actually means, and can it mean anything else? The answer is, of course, that the first law remains theoretically true even after the second has robbed it of practical meaning: the potentiality is still there but it is not “available.”

Since the discovery of radiation the theory has been advanced that the effective energy of the universe is constantly being replenished or restored by radiation changing back to matter just as matter is known to change into radiation. Millikan, Smuts, and the mathematician Bishop C. W. Barnes have

held this view. It is a “mechanical” theory which, in characteristic fashion, excludes as needless all consideration of animate nature, that world of life of which man is a part. So does Maxwell’s proposed sorting of molecules except that it would involve control by intelligence.

One of the greatest if not the most important of the problems of philosophy is to discover and define man’s relation to the universe. To explain how he is able to know about it, to perceive and to theorize, is the particular problem of epistemology. Many answers to these problems have been propounded since the early Greeks wrestled with them, and—in the Western World—they have had or lost validity commensurately with their conformity to the scientific knowledge of their time. As advancing scientific knowledge has required readjustments of thought when new and better concepts superseded older, less adequate ones, so have the philosophical and epistemological answers had to change. Science forced it upon them. And so, what with modern advances in science, philosophy may find itself compelled to seek new readjustments in its answers, perhaps even of a basic character.

These matters are not of academic interest only. The vital part played by systematic philosophy in the life of man is now well known. As F. S. C. Northrop has pointed out in *The Meeting of East and West*, the world has come at last to realize, through World War II and its aftermath, that our present “time of troubles” has its roots in conflicts of ideologies or philosophical understandings. By and large, such conflicts have lain close to the roots of war throughout history.

It is the purpose of this paper to outline—to sketch in impressionistic manner almost to the complete neglect of supporting argumentation and therefore dogmatically—a schematic concept, philosophical in character, which, despite its ultimate reliance on speculation, suggests in a new and different way how the energy of the universe may be in a constant process of restoration in effectiveness despite its dissipation. This novel concept may have a special interest because it does include the world of animate nature and finds a specific, even a necessary place for humanity in its philosophical discourse. And lest there be doubt as to the power of biological science to profoundly affect philosophical understandings, it may be well to recall that it was Aristotle, the very father of biology as a science, whose philosophy, powerfully influenced by his biological studies, became basic through St. Thomas Aquinas to the present or later (post-Augustinian) Roman Catholic orthodox doctrine, while it was Darwin who forced basic ideological change upon the modern world.

Through Darwin's insistence upon natural selection as a causative force in speciation, we now have a general acceptance of evolution in lieu of specific spontaneous creation. But—despite shifts away from and back to Darwinism—evolution still has no prophetic meaning. It looks backward, not forward, and few can derive much satisfaction from it as explanatory of man's place in nature's scheme of things and the course of human history, past, present, or future. While some authorities see evolution as a progressive process, their definition of progress (that it consists in greater control over or independence of environment) defines what is actually only a corollary of progress. They also deny that evolution has or can have any End, Purpose, or Objective, thus disregarding the difference between progress and mere progression. Other authorities hold that evolution is not progressive at all but is, on the contrary, regressive. Others, again, look upon it as nothing more than mere change. Evolution thus has its optimistic, pessimistic, and neutral schools of thought.

The uncertainty and confusion of thought thus evident comes, it would seem, from the

fact that all three schools fail to take into consideration what has the appearance of being the master biological-phenomenon of this planet.

That phenomenon is the so-called "pyramid of life," but especially the great mammalian pyramid to which man belongs and in which he finds his place. This figure of speech is a one-time well known expression epitomizing a biological truism. But, because it was as useless or merely curious an item of knowledge as the equally well known fact that (with only three known constant exceptions) all mammals have seven cervical vertebrae, it fell into disuse and is now so seldom employed as to make it require explanation, which will be made as brief as possible here.

The pyramid of life phenomenon results from two basic facts, with a supplementary third: (1) all living things require food or sustenance for their growth and maintenance; and (2) only vegetable forms of life can manufacture their own food, they having the power to transmute inorganic substance into organic. Therefore all other forms of life depend for their existence upon the green things of the earth, with such negligible exceptions as the sulphur and the iron bacteria as chemoautotrophs.

The supplementary third fact is that animal life evolved in two main, general classes with respect to food sources: herbivores and carnivores.<sup>1</sup> Hence a very large number of plants is required to sustain the necessarily smaller but still large number of herbivores which must die in order that one single carnivore may live. There is thus a diminution of number as life rises, level by level from plant to herbivore and from herbivore to carnivore. The second (herbivorous) level is superimposed upon the first (vegetal) level and the third (carnivorous) level is superimposed upon the second. This superimposition of level on level, together with the necessarily consequent diminution of number, is what gives the pyramid its figurative name.

<sup>1</sup> "In general, land animals fall rather sharply into herbivores and carnivores, and omnivorous types are exceptions rather than the rule." ALLEE, EMERSON, PARK, O., PARK, T., and SCHMIDT: *Principles of Animal Ecology*, p. 241. Philadelphia, 1949.

Each individual carnivore is the capstone of its own pyramid, but the phenomenon is world wide and so all those little, individual pyramids may be envisioned as components of one grand pyramid of worldwide extent. It is, however, a truncate pyramid, having no apex of numerical singularity.

Since there are many carnivore-including categories of lifeforms—birds, reptiles, fishes, insects, mammals, and so on—there are a corresponding number of particular pyramids, at least one for each such category, and the more primitive the category is, the less distinctly formed is its pyramid. But the only one which concerns us here is that one to which the mammals, including man, belong. For it alone has carried pyramid construction beyond the carnivorous level in such a way as to give promise of eventually producing an apical capstone for that worldwide structure. In so doing, it will more surely confirm what is here contended: that biological evolutionary progress is factual; that its perpetual landmarks are the successively superimposed levels of the grand, mammalian pyramid of life; and that the End toward which that progress marches is that pyramid's adumbrated eventual apex.

By and large, wherever there are plants, there also are feeders upon them; and wherever there are enough such feeders to sustain it, even briefly, there will carnivorous life be also. Thus the areas of aggregate territorial dominion are, in effect, the same for all three levels, and by identity. But each individual member of a superimposed (evolutionarily superior) level will, on an average and as compared with individual members of its imposed-upon level, exercise a greater expanse of that territorial dominion the assertion and maintenance of which is the price of existence among the living, a universal law of life with a wide range of application but no exceptions. This successive augmentation of individual territorial dominion, level by level, follows necessarily from the domination of the same territorial aggregate by a diminished aggregate of dominators. It is, indeed, simple arithmetic, for when the same dividend of aggregate dominion is divided among a decreased number of dominators as divisor, the quotient of average individual dominion must increase

in inverse proportion. (Halving the divisor doubles the quotient.)

Now, the atoms of physical matter are emergents in the sense of William Morton Wheeler's definition, which states that emergence in the scientific sense is "a novelty of behavior [new properties] resulting from the specific interaction or organization of a number of elements, whether inorganic, organic or mental, which thereby constitute a whole as distinguished from their mere sum or 'resultant'." For atoms are constituted of electrons, protons, neutrons, and so on, all specifically interacting to form a whole.<sup>2</sup>

The physical organisms of animate nature are also emergents in the same scientific sense, for they are constituted of cells, whether they be plants or animals and including biological man, the herbivorous and carnivorous levels of the pyramid being most fundamentally differentiated by their mode of securing sustenance. But the habits of predators require of them the constant exercise of superior mental powers. "It takes brains to stalk a prey; if the would-be eater is more stupid than his potential dinner, his chances are poor," says Alfred S. Romer in *Man and the Vertebrates*. Thus, it appears to be in carnivorous animal life that mind begins to assume particularly significant evolutionary value in the pyramid-building process, it becoming highly significant in man.

There are anatomical and historical reasons for believing that man had a carnivorous ancestry, and that he did not "come down from the trees," for he never was in them, as (among others) the African fossil primate known as *Proconsul* appears to indicate (W. E. Le Gros Clark). Man's erect posture seems to have been made possible by the shorter, less bulky and ponderous intestines characteristic of carnivores in general, as is also the frontal eye-placement permitting stereoscopic vision and favoring brain-case enlargement. These useful effects of the predatory habit, to which they are especially valuable, seem to be man's by inheritance. Not just meat-eating, but the morphological effects of the hunting habit

<sup>2</sup> Emergence, sometimes called epigenesis, violates the maxim that there can not be in the consequent anything more than or different in nature from that which was in the antecedent.

helped materially in making man the dominant physical organism that he is, and on a world wide scale.

All physical organisms—plants, animals, and human beings—when they die, make a final return to the general “atom bank” of the universe, that return consisting of the chemical elements composing their bodies at the time of death. This is a residual reversion back to matter by the disintegration of produced effects.

Expositions of the biological evolutionary process commonly carry it up to man and there they stop. There, “natural history” ends and “human history” begins. The general biologist is through, and the experts of the various disciplines which (in English-speaking countries) come under the omnibus heading of anthropology take over. In one way or another they all study man as what Aristotle said he is: namely, “a political animal,” which means one given to social organization.

Man shares with certain insects the distinction of being able to create societies which are just as much emergents in the sense of Wheeler’s definition as are atoms and physical organisms, being wholes or individualizations resulting from the specific interaction or organization of their constituting, living elements and exhibiting new properties as a direct consequence, in cultures and civilizations. It is worthy of note that the power of a human culture to advance to civilization seems to hinge upon its ability to accumulate and exploit conservable, need-supplying surpluses. These have been called “margins of vitality,”<sup>3</sup> and they may be of a material or an ideational character. The greater their number and diversity, the higher and more complex may be the stage of civilization attained.

In all societies the family appears to be the basic unit, comparable in that respect to the cell of physical organisms and to the atoms of matter. But the societies of the social insects are only grandiose families, and, being fiercely hostile to strangers even of their own kind, they have never produced more broadly constituted societies, whereas man has. The most stable large-scale human social organization is the nation, and the

<sup>3</sup> HASKINS, CARYL P.: *Of Societies and Men*, p. 231. New York, 1951.

position here taken is that nations, however constituted politically, are true organisms which, in aggregate, form a new and higher level in the mammalian pyramid of life, thus carrying the evolutionary process on *beyond man* as an accomplished fact. In the pyramid of life so viewed, national societies constitute a level higher than and superior to man by the same general, source-of-sustenance criterion of superiority valid with respect to other levels in it, that sustenance now being the aggregated, composite mental activity of the human sustainers, institutionally embodied and organized. But individual man, in the role of sustainer, has an evolutionary priority which cannot be reversed and which steadily becomes increasingly significant, even from the strictly evolutionary point of view, as the sustenance-supplying value of cultivated human intellects is more and more heavily accented in the course of history and democracy as a political system (which alone it is) approaches the ideal of private liberty and public order successfully maintained in balance, one against the other.<sup>4</sup>

Analytical study of the mammalian pyramid of life up to and including the level of the carnivores reveals the following principles, which appear to be universal with respect to it:

I. The law of territorial dominion. (In one or more of a great variety of possible ways, every individual must rule the source of its sustenance or lose its liberty if not its life.)

II. All evolutionary superiors depend for their existence upon the prior and continued existence of their evolutionarily inferior sustainers. (A lower level must precede a higher.)

III. Diminution of number, level by level.

IV. Identity of aggregate territorial dominion for all levels. (Each level must finally establish worldwide dominion.)

V. Increased individual territorial dominion in inverse proportion to diminution of

<sup>4</sup> Public order (governmental organization) is essential to community life, while the greatest degree of private liberty consistent therewith alone can give effective expression to those superior, creative mentalities which may appear sporadically in all levels of society by whatever criterion and which cannot be predicted. Only democracy can well assure both these desirables.

number. (A necessary consequence of III and IV as previously noted.)

All these principles apply with full force to societies, both insect and human, and, in this paper, nations, as true organisms, are held to constitute a new level of existential reality: the mental or psychozoic.

It was when man, adopting systematic agriculture, began to form sedentary societies that he was forced to become definitely omnivorous, just as were the nesting ants despite their carnivorous ancestry, they having evolved from wasps. For only vegetable sources can furnish the abundant and dependable food supply required by a populous, permanently located society, while meat-hunger persists for both phylogenetic and physiological reasons, meat still being man's most perfect natural food.

It has been argued (among other reasons) that nations do not qualify as organisms because they have no natural span of life. But there are arguments, not adducible here, which, in rebuttal, suggest that should nations actually have such a life span, history is still too brief to reveal it. Nations do, however, cease to be, and when they do they may leave archeological remains comparable to the fossil remains of physical organisms. Here, too, there appears to be a residual reversion to the "atom bank" of the universe, also by the disintegration of produced effects.

In recent years the vision of a unitary World Order has risen once again as it has risen repeatedly in the mind of man through the ages. There is reason to believe that realization of that vision is at last approaching the possible but that it is contingent upon the prior formation of (cultural?) regional supranational organizations if not organisms. Only when they first shall have been constituted in permanence does it seem probable that the vision of One World can later be realized. And in that realization, far in the future though it now may lie, our planetary mammalian pyramid of life will find its apex.

One of the greatest obstacles to such realization is that only democratic nations as known in the West seem able to cooperate in harmony, wherefore they alone appear to give promise of carrying the process to its apical End, its Final One of diminution of

number, and democracy is still only a Western phenomenon. But back of that lies the still greater difficulty that One World cannot permanently eventuate until one basic philosophy is common to the nations. The pyramid of life concept—giving meaning to the evolutionary process such as it does not now have and stressing the cooperative, organizing impulse as primary therein—could become the cornerstone of such a philosophy, rooted in natural law and growing logically from it as all valid philosophies must, or must appear to in the light of the scientific knowledge of their time.

The pyramid of life concept, however, will not be adequate if it can be said that it is valid for our planet alone. No matter how much its present faults (the inevitable concomitants of innovational incipency) may be corrected and its truths elaborated and confirmed, even to the point of gaining for it a general acceptance, it will still remain a fact that the earth is but an infinitesimal part of the universe. What happens here may be quite insignificant as measured against the immensity of the cosmos. And modern scientists are cosmic minded. There has lately been a veritable spate of mathematically conceived cosmologies: Einstein's, de Sitter's, Le Maitre's, Tolman's, and others. Latest of all is Hoyle and Lyttleton's.

Astronomical science no longer asserts that the earth is the only inhabited planet. Most of our leading astronomers now agree that there are literally thousands of planets scattered through the cosmos on some of which life as we know it not only can but probably does exist. And that is interesting indeed, for *life as we know it means pyramid-building life!* Perhaps those "dark companions," especially those planets which are life-bearing planets, may have greater significance than we yet realize. The very numerosity of them would seem to suggest some cosmic relation in life's evolutionary process.

These are problems whose answers we may never know with any degree of certainty. But the mind reasons. It imagines and theorizes. Indeed, the first step toward the formulation of scientific theory often is the use of the imagination to make tentative, exploratory guesses. It is legitimate so to use the imaginative faculty if it is logically employed and its fruits subjected to such

experimental or observational tests as can be devised. Should that be impossible, there can be no more than a hypothesis, not even a working hypothesis but merely speculation pure and simple. Yet that, too, can serve if it must. So let us consider.

One of the characteristics of the pyramid of life as we know it is that there is an evident successive refinement and concentration of energy in the form of sustenance and "margins of vitality" as life rises through its realms and levels, its source-of-sustenance-determined fields of actuality. It may therefore not untruthfully be said that by the worldwide pyramid-building process life gathers and builds up energy stores in more and more concentrated-by-refinement form: from gross vegetable matter to animal; from animal to self-conscious, perceptive mentality. Thus are created the vegetable kingdom, the animal kingdom, and the kingdom of the mind. And always there appears to be a residual reversion back to the universal "atom bank."

If, now, this is not merely an isolated phenomenon but is a cosmic one, then may it not be possible—and here imagination takes wings indeed!—that as planetary pyramids evolve their apical capstones there is another, a fourth transmutation, by which energy is still further refined and concentrated, to be sent forth to sustain some Ultimate Unity of the Universe, the Final One of *cosmic* diminution of number, a cosmic Final One whose area of territorial dominion is the cosmos itself? And if again there is that residual reversion after use, would it not most probably be in the form of the stuff of which the "dead" matter of the physical universe is made?

Wild as this speculation may seem, there may be more than a little truth in it. It might, for example, account for that new hydrogen which Hoyle and Lyttleton's mathematical cosmology postulates as continually appearing but coming from they know not where. For hydrogen is the commonest, most plentiful and, at the same time, the most basic of all the chemical elements. It is out of hydrogen "pennies" that the larger "coins" of the "atom bank" of the universe are made, releasing the "packing fraction" energy of fusion in the process.

Should all this be indeed true, then it would seem that life has a cosmic function by which the operation of the second law of thermodynamics is offset and counteracted, reminiscent of Newton's law of action and reaction. Thus may the "heat death" of the universe be made forever impossible.

Here we are dealing with something akin to the postulated existence of God: no one can prove it, but neither can anyone disprove it. Yet the charge of insufficiency of theoretic range of applicability of the pyramid of life concept can at least be met and challenged.

Objections to this speculative conclusion can, of course, be raised. Only two will be noticed here.

First, the expanding universe theory based on Hubble's observed shift to the red end of the spectrum, increasing with distance, is now seen to require the continual appearance of new hydrogen in order to keep the average density of the matter of the universe constant despite that expansion, and the velocities involved are so great that far more hydrogen is required to appear than any conceivable number of planetary life pyramids could possibly supply by any process of transmutation and residual reversion. Any such speculative conclusion is therefore completely negated by the expanding universe theory.

In rebuttal, it can be said that the expanding universe theory is only one of several scientifically satisfactory explanations of that "Doppler effect." It might, for example, actually be a sort of "Compton effect" produced by the passage of the light rays through the intervening "cosmic dust," reducing their energy and lengthening them, an effect also increased by distance. The expanding universe theory objection is of questionable validity.

Second, no reference to life is necessary since the newly appearing hydrogen is held to be a true creation, being made *out of nothing*, says Sir Harold Spencer Jones, British Astronomer Royal.<sup>5</sup> This is indeed a bold, almost an outrageous assumption. How desperate must the case be when such measures have to be resorted to! One is reminded of

<sup>5</sup> *The Listener* (July 17, 1952), London. Condensed in *Science Digest*, November 1952, p. 56.

Bertrand Russell's remark: "It is the privilege of pure mathematicians not to know what they are talking about." Compared to this, the demands upon credulity made by the speculative conclusion advanced in this paper as to life's cosmic function are mild indeed! And it does not require nullification of the first law of thermodynamics, as this postulation of such newly created hydrogen does. What it does require is merely that the evolutionary process should continue to operate precisely as it has through countless millennia and follow the same general pattern with that consistency for which nature is famous.

Brushing aside now the thousand and one objections of detail which can be raised against the pyramid of life concept (most of which seem to have their satisfying answers), let us turn to an aspect of it which may escape notice. It is that through that concept we can have an idea of how the mechanical, chemico-physical world of matter and the

world of animate nature are joined at—so to speak—both ends of the latter. Their differentiation begins when inorganic substance is transmuted into organic. Then the process of building up the grand, mammalian pyramid, supported by lesser, subsidiary ones, proceeds in an ordered manner, gathering and concentrating energy as it rises. It ends in the pyramidal finality of numerical singularity and the fulfillment of its cosmic function by (the electromagnetic forces of?) life. Then, by residual reversion, matter returns to its condition at the starting-point, closing the cycle of this continuous process. Thus do we obtain an idea of the animate and inanimate worlds as complementary phenomena, two interacting, reciprocal parts of one great whole.

Is it not time for cosmologists, mathematical or otherwise, to take notice of the fact that life, too, may be of cosmic significance, and to admit consideration of it into their calculations? It would seem so.

PALEONTOLOGY.—*Notes on some Mesozoic fossil fish remains from Mexico.*<sup>1</sup>

DAVID H. DUNKLE, U. S. National Museum, and M. MALDONADO-KOERDELL, Petroleos Mexicanos.

The remains of two identifiable fossil fishes have been recovered recently from horizons in the sequence of upper Jurassic and lower Cretaceous rocks near Tamán, San Luis Potosí, Mexico. The surprisingly deficient record of marine fishes of these ages in the Western Hemisphere has prompted study of the present materials and suggested the desirability of publishing the following observations.

The region about Tamazunchale and Tamán in the State of San Luis Potosí has attracted the attention of several geologists during the past 30 years. Heim (1926, pp. 84-87, 2 figs.) was the first to offer a gross account of the rock formations outcropping between Tamazunchale, Tamán, and Pimienta, a village on the Río Moctezuma a short distance southwest of Tamán. In the geologic column elaborated from his field

observations, Heim recognized a thick sequence of Jurassic sediments overlain by a limestone which although very similar to the Tamasopo limestone was given the new name Tenestipa formation and considered, according to the ideas of the time, of lower middle Cretaceous age. The Jurassic section was conceived as of two parts; a lower formation called the Tamán beds assigned a Kimmeridgian age on the basis of fossils collected in the valley of the Río Moctezuma at and east of Tamán; and an upper unfossiliferous formation named the Pimienta beds tentatively referred to the Portlandian stage of the upper Jurassic.

Burkhardt (1930, pp. 90-91, fig. 28) in speaking of the Tamazunchale-Tamán section, stated that the Jurassic strata there were simply the northwestern extremity of outcrop of the Liassic and "suprajurassic" formations of the Huasteca region. In addition he considered the highly folded and faulted Tamán beds, reported by Heim as measuring more than 1,000 m in thickness,

<sup>1</sup> The original fish specimens herein described are retained in the private collection of the junior author. Replicas, however, have been deposited in the U. S. National Museum.